Geophysical Research Abstracts
Vol. 21, EGU2019-425, 2019
EGU General Assembly 2019

Decomposing the seasonal variability of flushing characteristics in a tidal bay along the North Sea

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Flushing timescales (e.g., turnover time, residence time) in estuaries and coastal bays shape the spatiotemporal distribution patterns of dissolved and particulate matters (e.g., nutrients, chlorophyll-a, dissolved oxygen, trace metals, bacteria) to a large extent and therefore have important environmental implications. In this study, we investigated the spatiotemporal variability of flushing capability in a semi-enclosed tidal bay (the Oosterschelde, the Netherlands) on the east coast of the North Sea. Using a calibrated and validated three-dimensional hydrodynamic model, the Eulerian conservative tracer experiments were conducted to estimate the turnover time in the Oosterschelde, which range from 0 to over 150 days from the seaward to landward ends and display significant seasonal variability, especially in the central and eastern parts. Sensitivity scenarios were run to examine the relative role of individual forcing agents in driving the seasonal variability. Results indicate that winds and gravitational flow contribute most to the seasonal variability of the turnover time in the Oosterschelde. Freshets from the Westerschelde and Rhine River can reduce the axial density gradient and exchange gravitational flow, which increase the turnover time of the basin. As the prevailing winds of the year, southwesterly winds of sufficient magnitude (> 5 m/s) could modify the spatial patterns of the turnover time, especially in shallow waters. Although tides force the flushing of the bay, the starting tidal amplitude (spring-neap cycle) does not induce significant seasonal variability. The impacts of freshwater input, both baroropic and baroclinic, are mainly regional and limited to the northern branch. Findings in this study help understand the transport processes in the Oosterschelde, provide the physical background for the future biogeochemical and ecological studies, and facilitate intercomparison of the flushing capacity with other tidal bays with limited freshwater input.